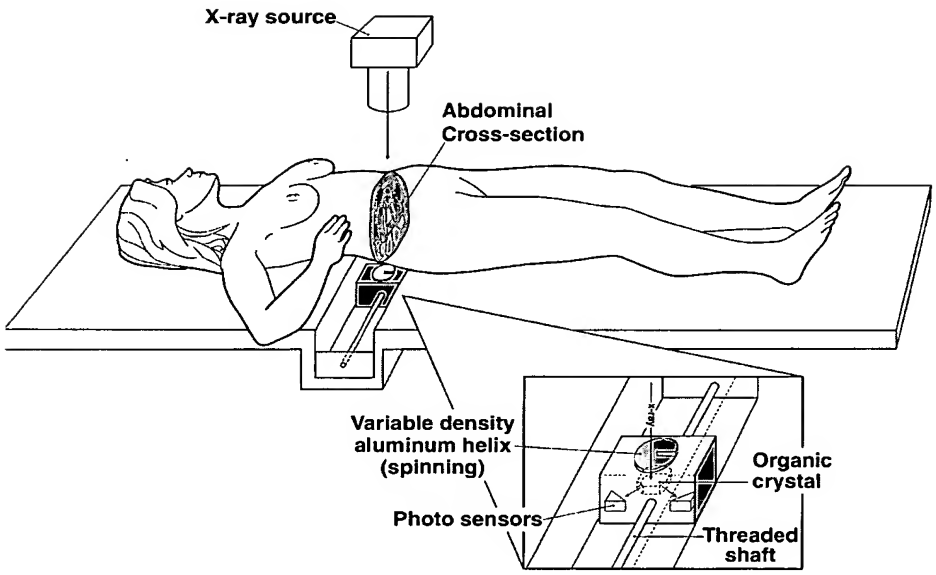
X-ray source
Abdominal Cross-section
Variable density aluminum helix (spinning)
Photo sensors
Organic crystal
Threaded shaft

FIG. 1

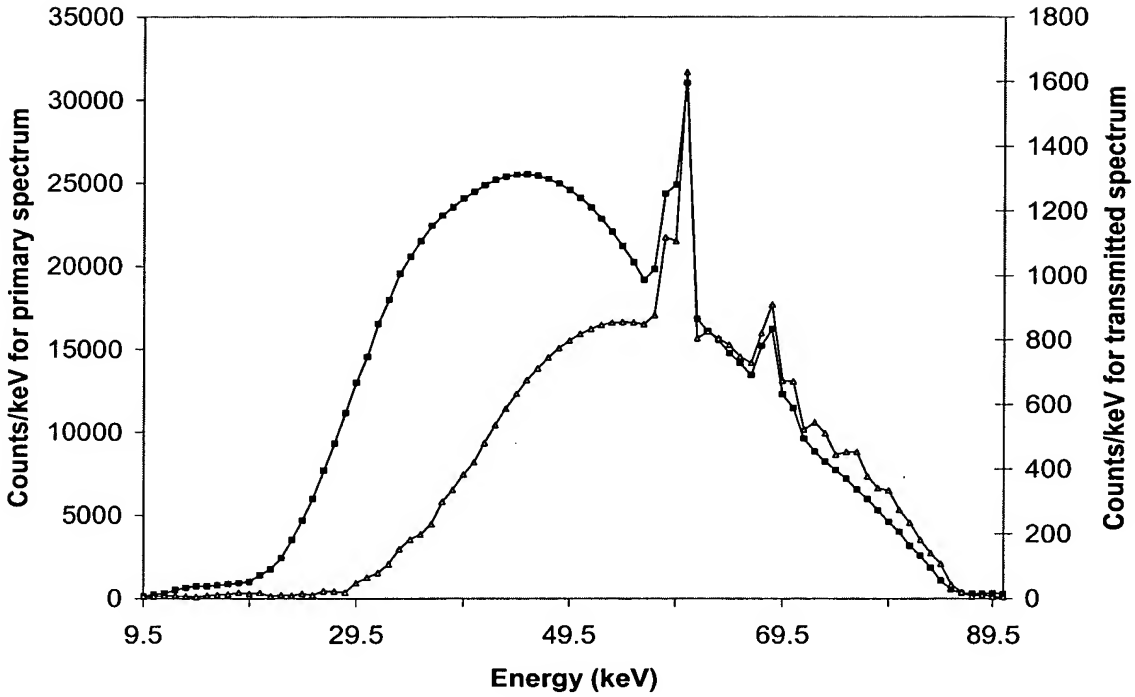
35000
30000
25000
20000
15000
10000
5000
0
Counts/keV for primary spectrum
1800
1600
1400
1200
1000
800
600
400
200
0
Counts/keV for transmitted spectrum
9.5
29.5
49.5
69.5
89.5
Energy (keV)

FIG. 2

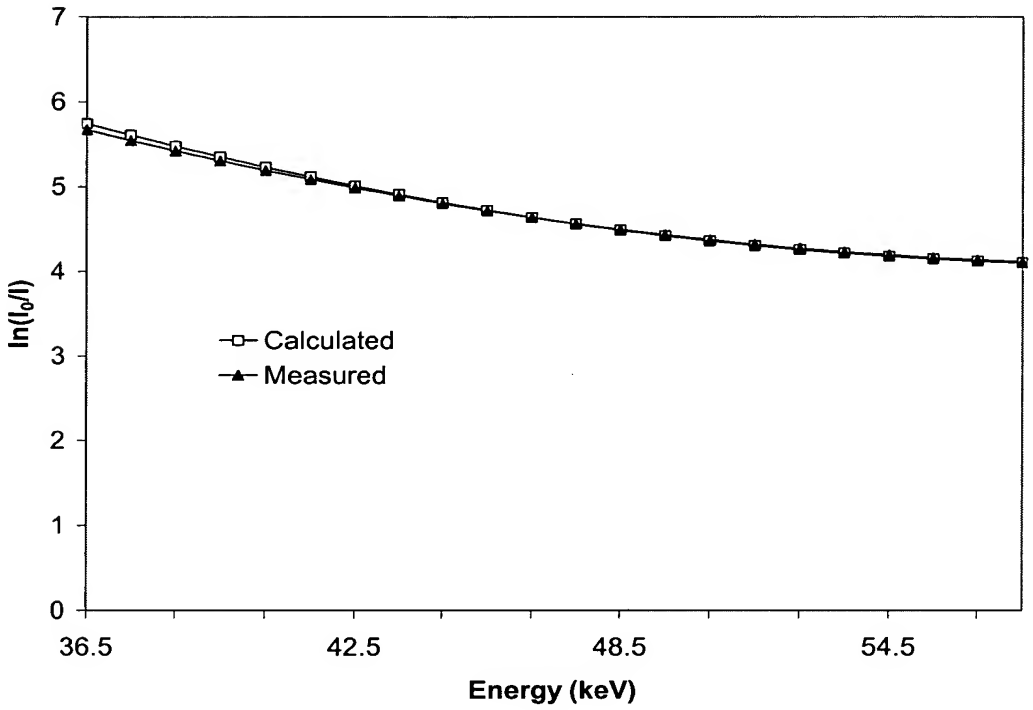
7
6
5
4
3
2
1
0
ln(I0/I)
Calculated
Measured
36.5
42.5
48.5
54.5
Energy (keV)

FIG. 3

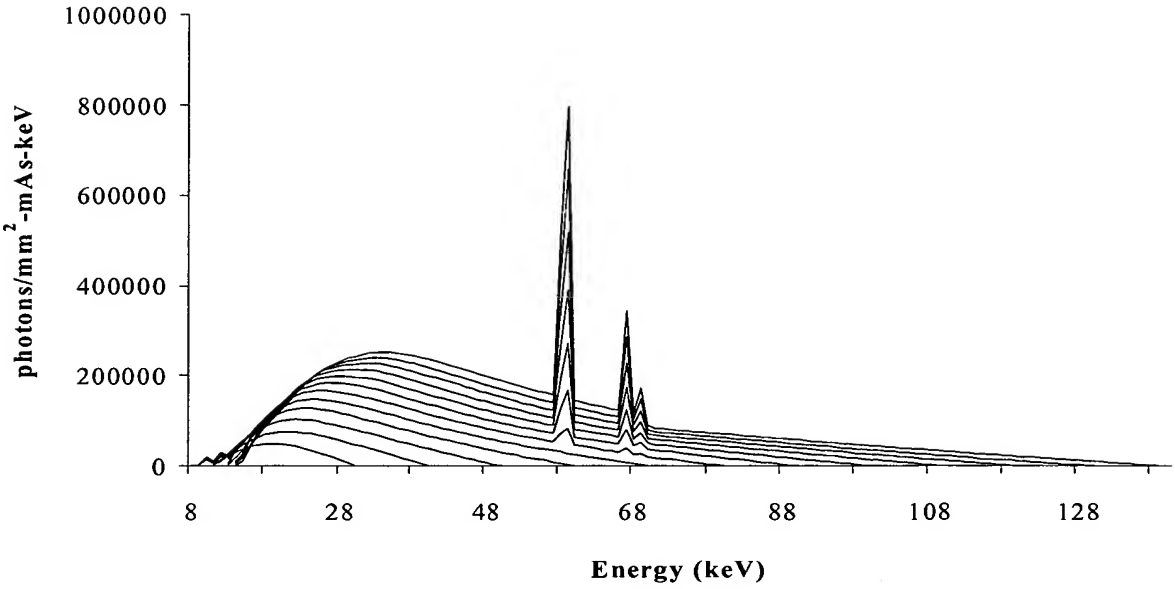
1000000
800000
600000
400000
200000
0
photons/mm^2-mAs-keV
8
28
48
68
88
108
128
Energy (keV)

FIG. 4

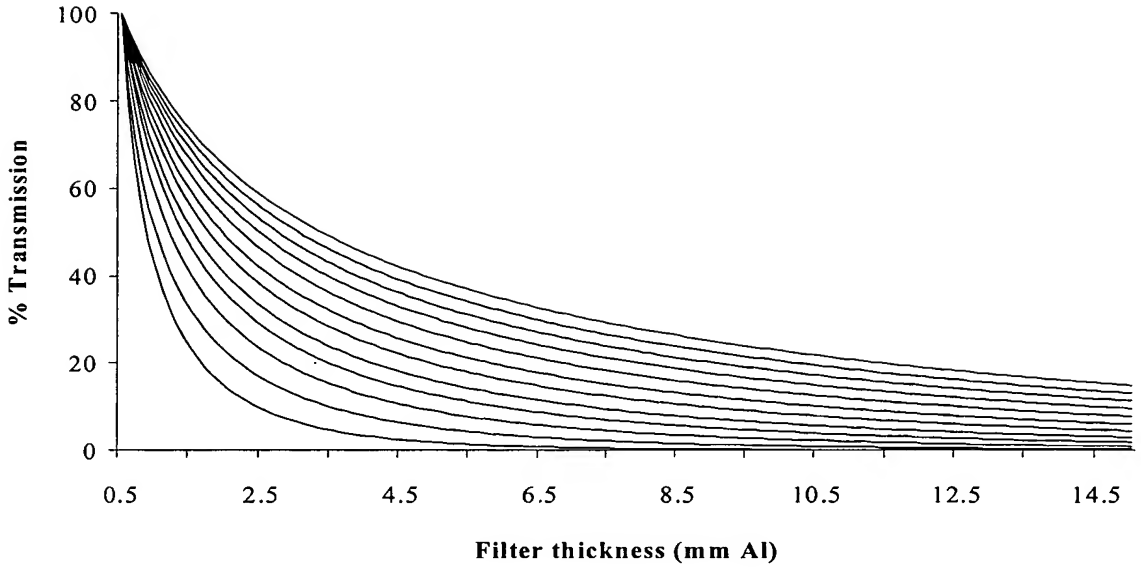
100
80
60
40
20
0
% Transmission
0.5
2.5
4.5
6.5
8.5
10.5
12.5
14.5
Filter thickness (mm Al)

FIG. 5

```
FOR kg1=Lower Limit kg1  to Upper Limit kg2  step kg1step(usually 0.001 or 0.0005)
    FOR kg3=Upper Limit kg3 to Lower Limit kg3 step –kg3(usually 0.001 or
0.0005)
       LET kg2=1-kg1-kg3
       IF kg2>Then Kg2 input lower limit and kg2<Kg2 Upper Limit  then
         CALL loop
       END IF
    NEXT kg3
  NEXT kg1

SUB loop
  LET rhoxg(p5,1)=kg1*sumrhoxg
  LET rhoxg(p5,2)=kg2*sumrhoxg
  LET rhoxg(p5,3)=kg3*sumrhoxg
  LET sumdif=0
  FOR i=Energy lower limit to Energy Higher Limit step 1 keV
    LET argguess(p5,i)=murhosofttissue(i)*rhoxg(p5,1)
    LET argguess(p5,i)=argguess(p5,i)+murhofat(i)*rhoxg(p5,2)
    LET argguess(p5,i)=argguess(p5,i)+murhobone100(i)*rhoxg(p5,3)
    LET sumdif=sumdif+abs(argpoly2(p5,i)-argguess(p5,i))
  NEXT i
  IF sumdif<sumdifbest(p5) then
    LET sumdifbest(p5)=sumdif
    LET kg1best(p5)=kg1
    LET kg2best(p5)=kg2
    LET kg3best(p5)=kg3
    LET rhoxgbest(p5,1)=rhoxg(p5,1)
    LET rhoxgbest(p5,2)=rhoxg(p5,2)
    LET rhoxgbest(p5,3)=rhoxg(p5,3)
  END IF
END SUB
```

FIG. 6

Description	C Carbon	O Oxygen	H Hydrogen	N Nitrogen	Ca Calcium	P Phosphorus	Cl Chlorine	Physical density
Adipose	0.724	0.155	0.094	0.023	0.0025	0	0.002	0.967
Muscle	0.697	0.168	0.091	0.021	0.022	0	0.001	1.062
Trabecular Bone 100 mg/cc	0.622	0.203	0.084	0.017	0.057	0.014	0.0016	1.084

FIG. 7

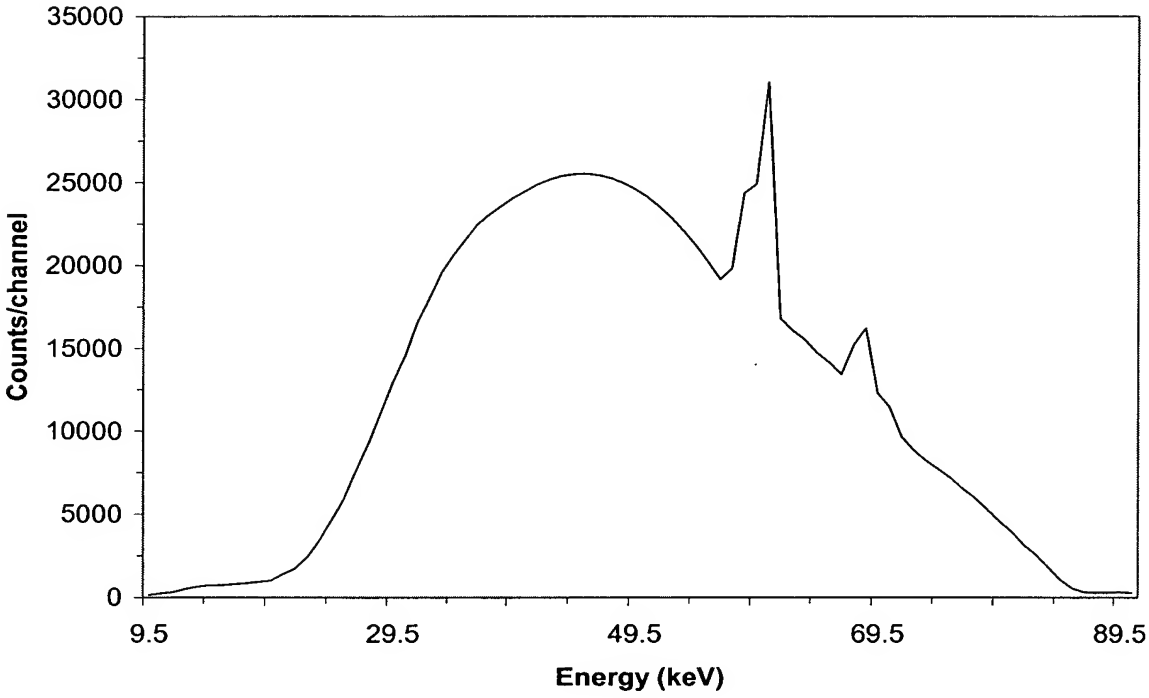
35000
30000
25000
20000
15000
10000
5000
0
Counts/channel
9.5
29.5
49.5
69.5
89.5
Energy (keV)

FIG. 8

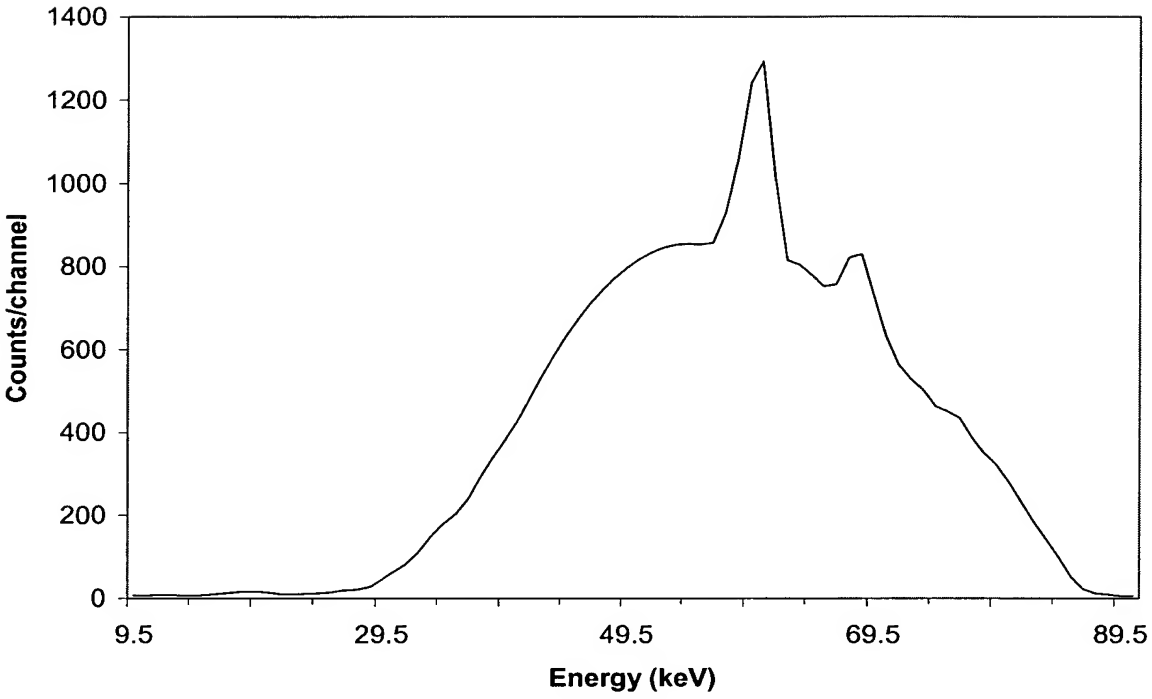
1400
1200
1000
800
600
400
200
0
Counts/channel
9.5
29.5
49.5
69.5
89.5
Energy (keV)

FIG. 9

Phantom number	Areal densities (cm^2/g)		
	Muscle	**Adipose tissue**	**Bone**
Phantom 1	21.24	2.901	1.084
Phantom 2	15.93	2.901	1.084
Phantom 3	15.93	6.769	1.084
Phantom 4	15.93	2.901	2.168
Phantom 5	10.62	2.901	1.084

FIG. 10

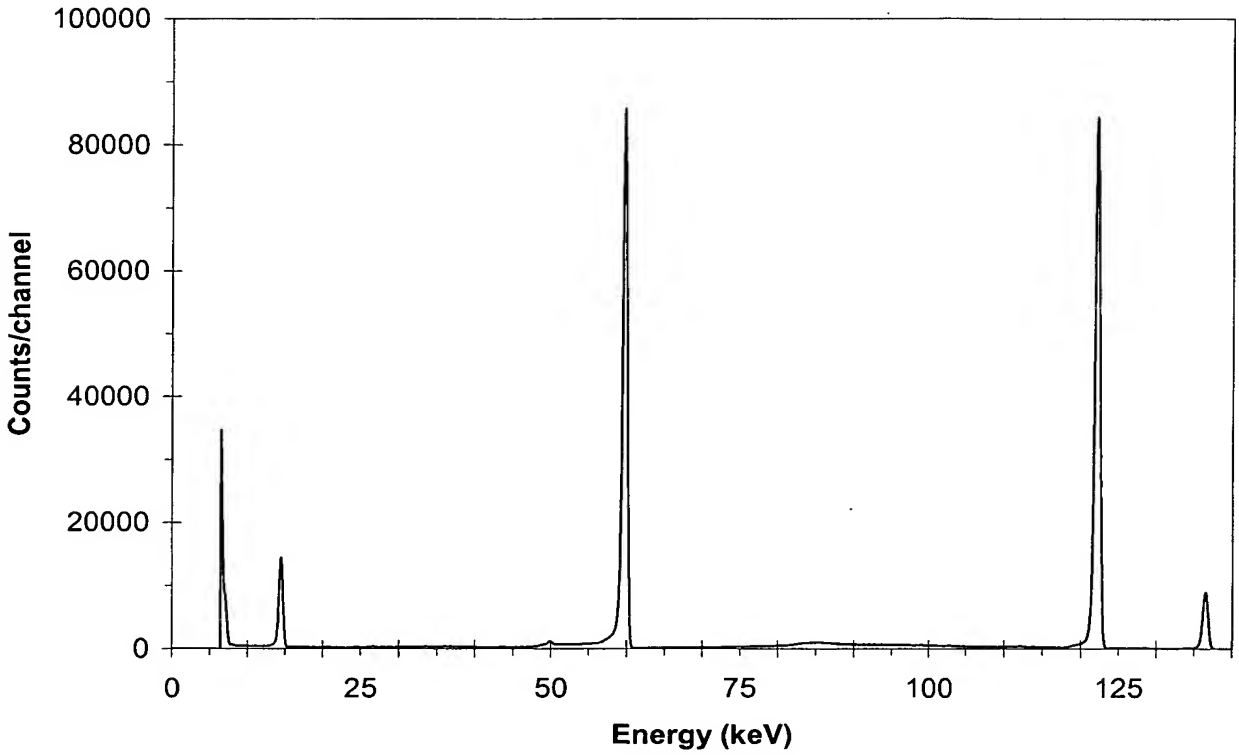
100000
80000
60000
40000
20000
0
Counts/channel
0
25
50
75
100
125
Energy (keV)

FIG. 11

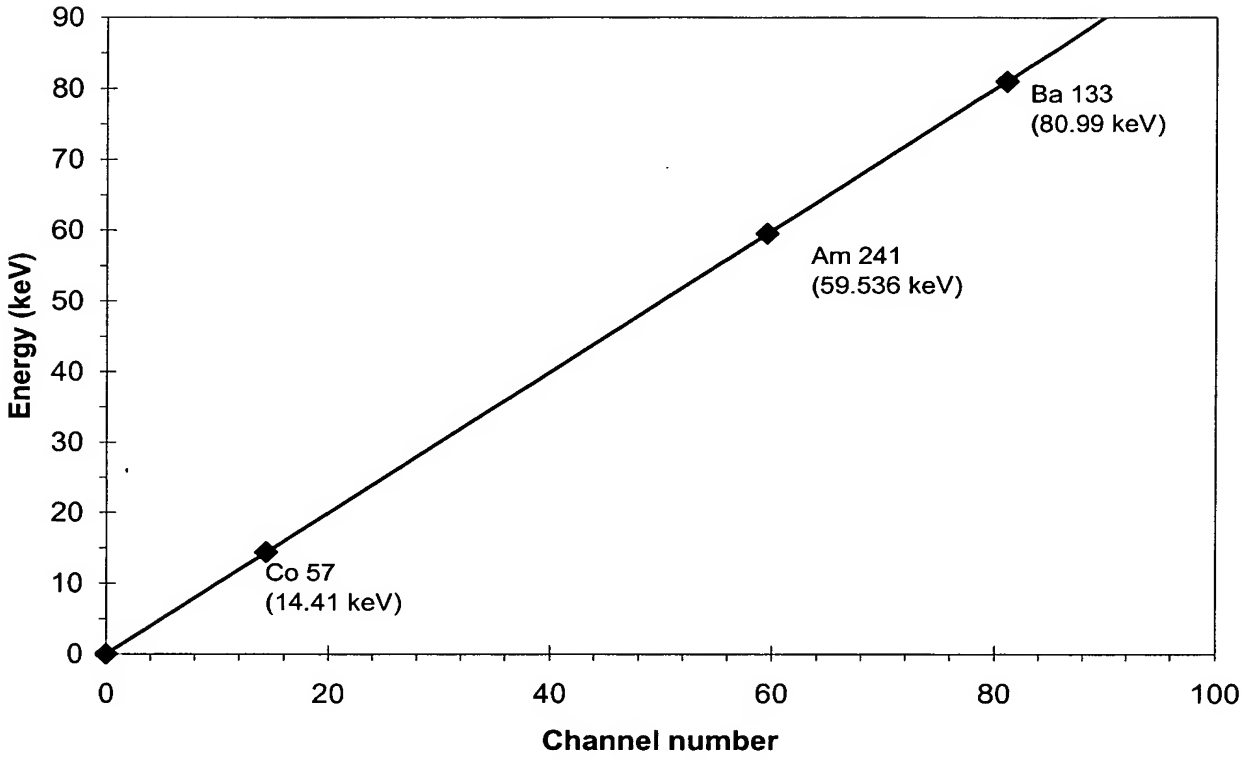
Energy (keV)
Channel number
0
10
20
30
40
50
60
70
80
90
0
20
40
60
80
100
Co 57
(14.41 keV)
Am 241
(59.536 keV)
Ba 133
(80.99 keV)

FIG. 12

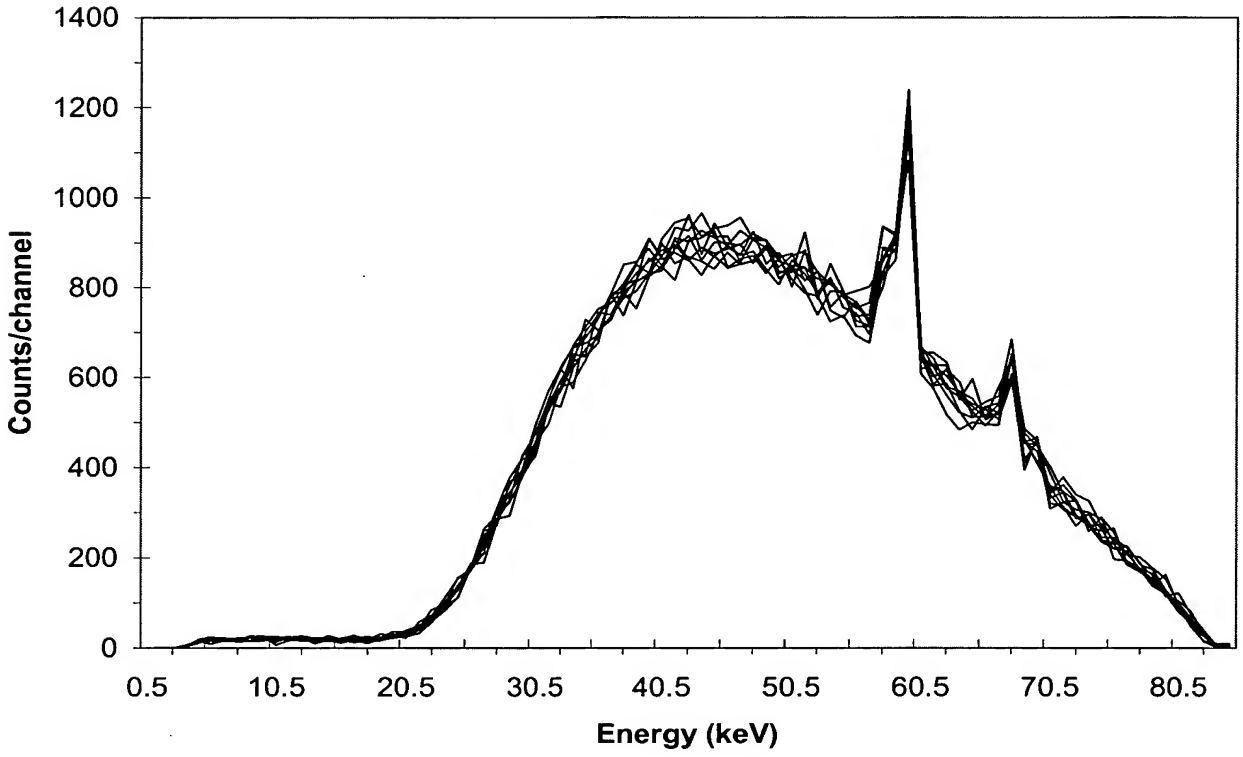
1400
1200
1000
800
600
400
200
0
Counts/channel
0.5
10.5
20.5
30.5
40.5
50.5
60.5
70.5
80.5
Energy (keV)

FIG. 13

keV	Mean	SD	CV
36.5	766	8.75	0.0114
37.5	793	8.91	0.0112
38.5	820	9.06	0.0110
39.5	858	9.26	0.0108
40.5	867	9.31	0.0107
41.5	892	9.44	0.0106
42.5	902	9.50	0.0105
43.5	892	9.44	0.0106
44.5	898	9.48	0.0106
45.5	888	9.42	0.0106
46.5	885	9.40	0.0106
47.5	890	9.43	0.0106
48.5	880	9.38	0.0107
49.5	848	9.21	0.0109
50.5	844	9.19	0.0109
51.5	842	9.18	0.0109
52.5	797	8.93	0.0112
53.5	795	8.91	0.0112
54.5	772	8.78	0.0114
55.5	745	8.63	0.0116
56.5	728	8.53	0.0117
57.5	869	9.32	0.0107
		Average	**0.0109**

FIG. 14

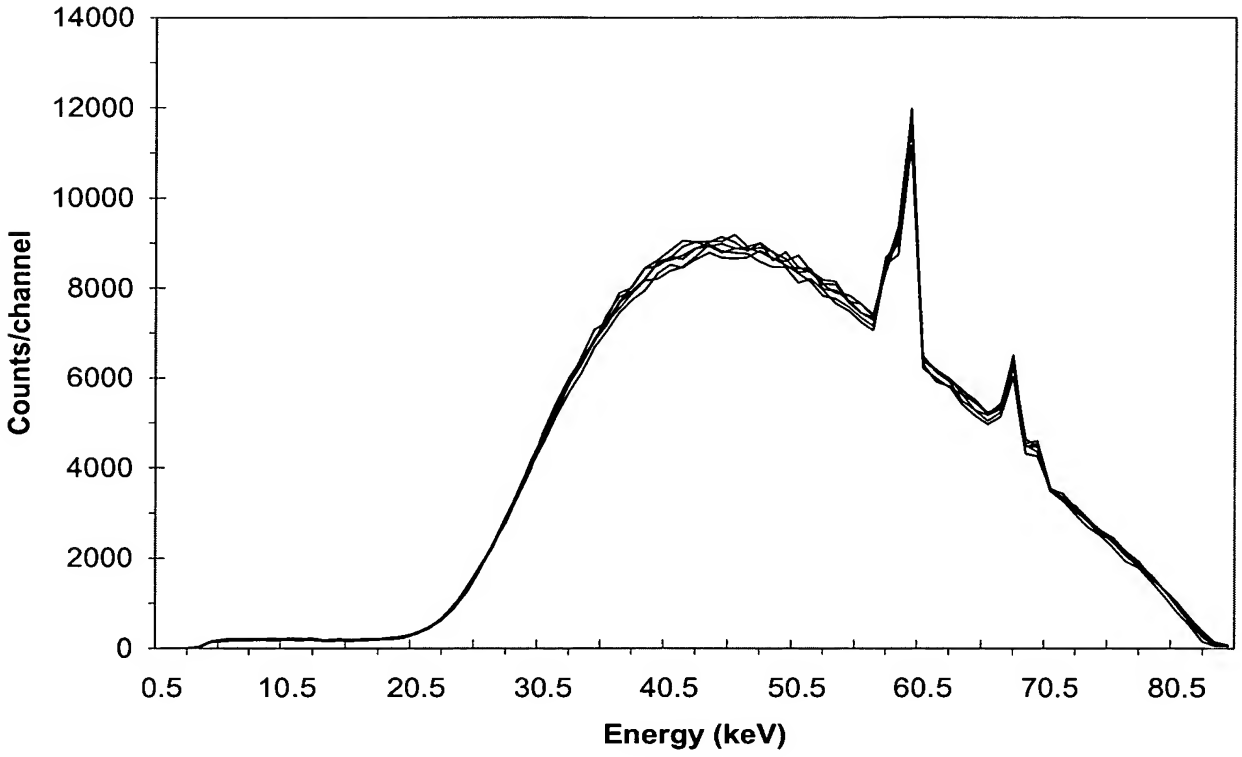
14000
12000
10000
8000
6000
4000
2000
0
Counts/channel
0.5
10.5
20.5
30.5
40.5
50.5
60.5
70.5
80.5
Energy (keV)

FIG. 15

keV	Mean	SD	CV
36.5	10232	41.30	0.0040
37.5	10561	41.95	0.0040
38.5	10973	42.76	0.0039
39.5	11286	43.37	0.0038
40.5	11494	43.77	0.0038
41.5	11612	43.99	0.0038
42.5	11800	44.35	0.0038
43.5	11918	44.57	0.0037
44.5	11870	44.48	0.0037
45.5	11862	44.46	0.0037
46.5	11756	44.26	0.0038
47.5	11795	44.34	0.0038
48.5	11546	43.87	0.0038
49.5	11444	43.67	0.0038
50.5	11206	43.22	0.0039
51.5	11082	42.98	0.0039
52.5	10688	42.21	0.0039
53.5	10549	41.93	0.0040
54.5	10220	41.27	0.0040
55.5	9953	40.73	0.0041
56.5	9695	40.20	0.0041
57.5	11264	43.53	0.0038
		Average	**0.0039**

FIG. 16

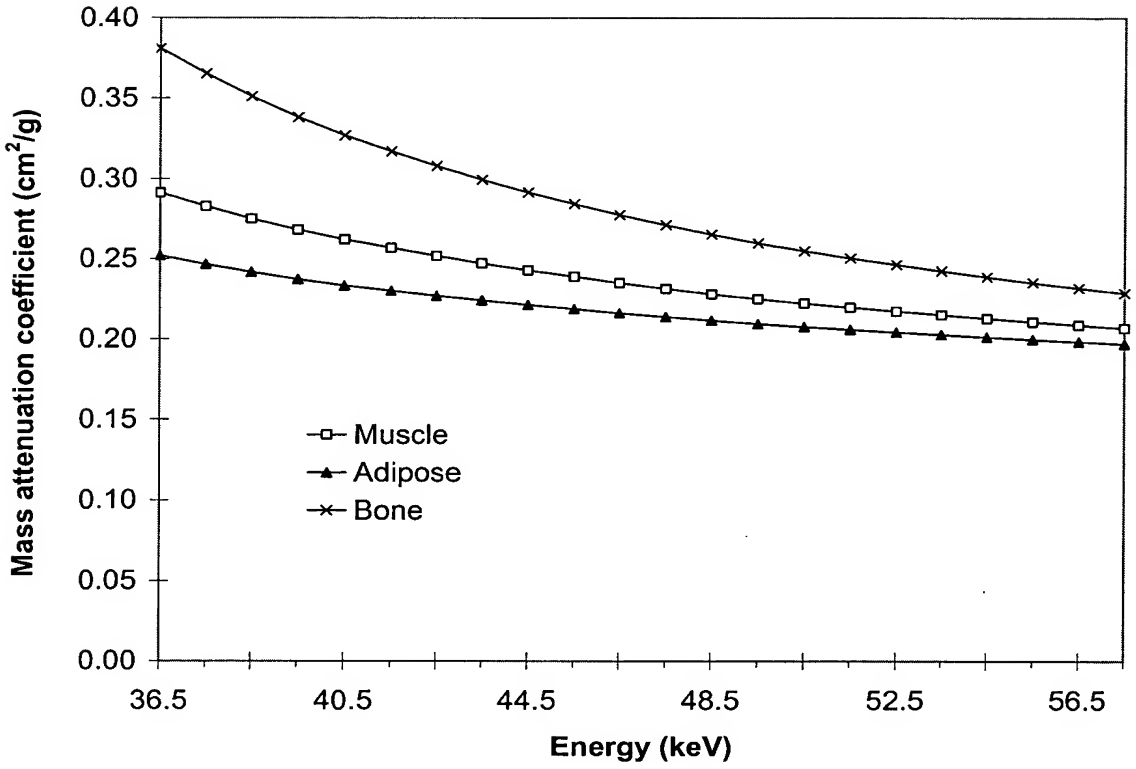
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Mass attenuation coefficient (cm²/g)
Muscle
Adipose
Bone
36.5
40.5
44.5
48.5
52.5
56.5
Energy (keV)

FIG. 17

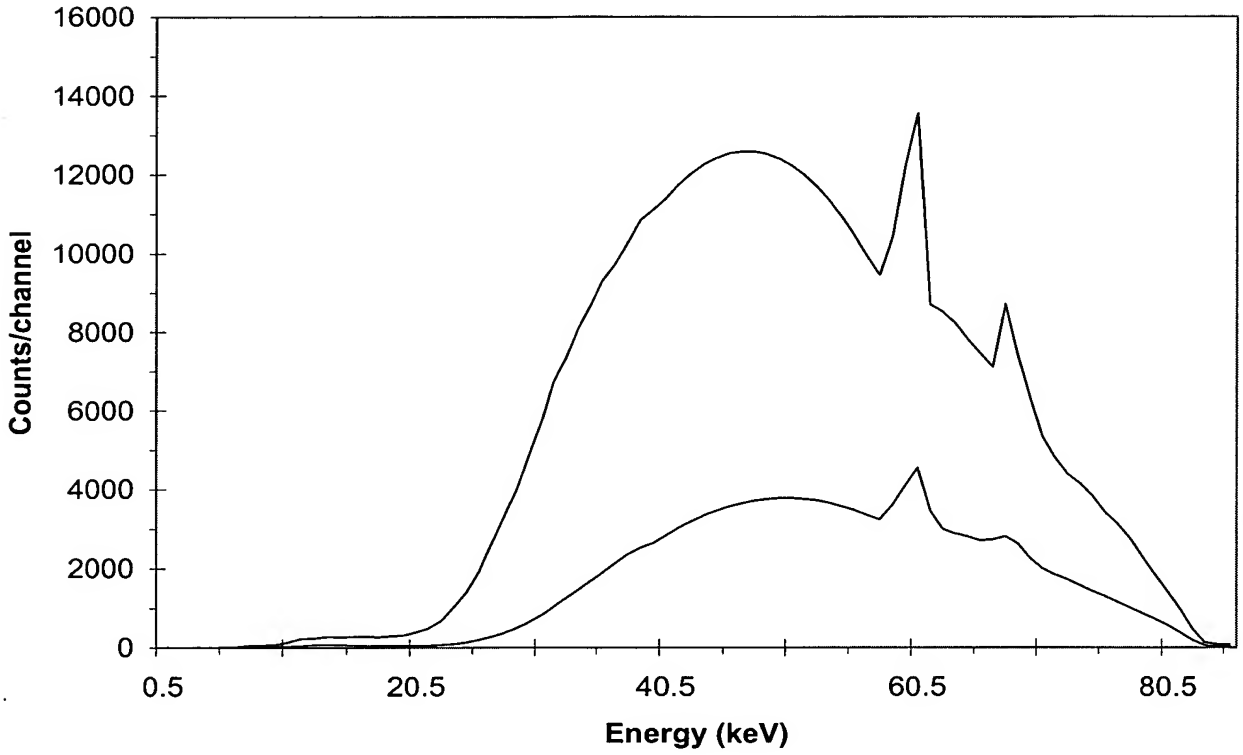
16000
14000
12000
10000
8000
6000
4000
2000
0
Counts/channel
0.5
20.5
40.5
60.5
80.5
Energy (keV)

FIG. 18

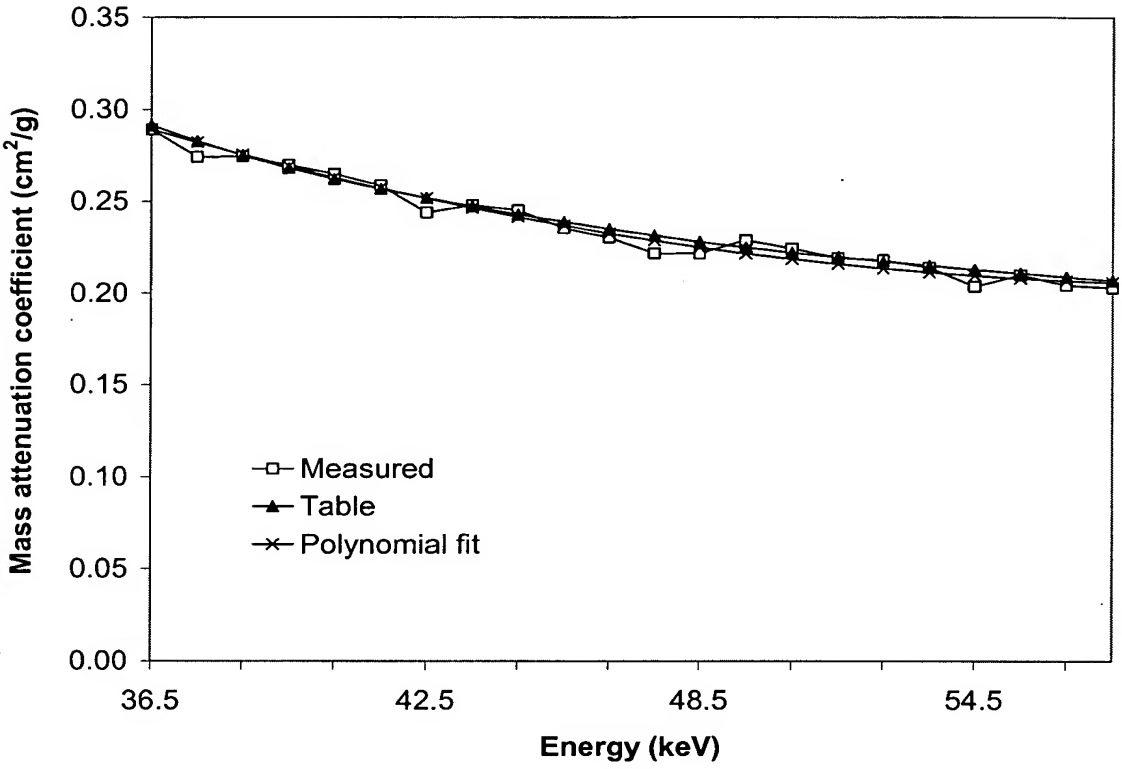
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Mass attenuation coefficient (cm²/g)
Measured
Table
Polynomial fit
36.5
42.5
48.5
54.5
Energy (keV)

FIG. 19

keV	μ/ρ experim.	μ/ρ theoret.	Ratio	$\sigma_{(\mu/\rho)}$
36.5	0.2891	0.2913	0.993	0.0045
37.5	0.2821	0.2828	0.998	0.0043
38.5	0.2754	0.2750	1.001	0.0042
39.5	0.2690	0.2680	1.004	0.0041
40.5	0.2628	0.2620	1.003	0.0040
41.5	0.2570	0.2567	1.001	0.0039
42.5	0.2516	0.2518	0.999	0.0037
43.5	0.2464	0.2472	0.997	0.0037
44.5	0.2415	0.2428	0.994	0.0036
45.5	0.2369	0.2388	0.992	0.0034
46.5	0.2326	0.2350	0.990	0.0034
47.5	0.2287	0.2314	0.988	0.0035
48.5	0.2250	0.2281	0.987	0.0035
49.5	0.2217	0.2250	0.985	0.0035
50.5	0.2186	0.2222	0.984	0.0036
51.5	0.2159	0.2197	0.982	0.0036
52.5	0.2134	0.2173	0.982	0.0036
53.5	0.2113	0.2150	0.983	0.0036
54.5	0.2095	0.2128	0.984	0.0036
55.5	0.2080	0.2107	0.987	0.0037
56.5	0.2067	0.2087	0.991	0.0037
57.5	0.2058	0.2068	0.995	0.0037

FIG. 20

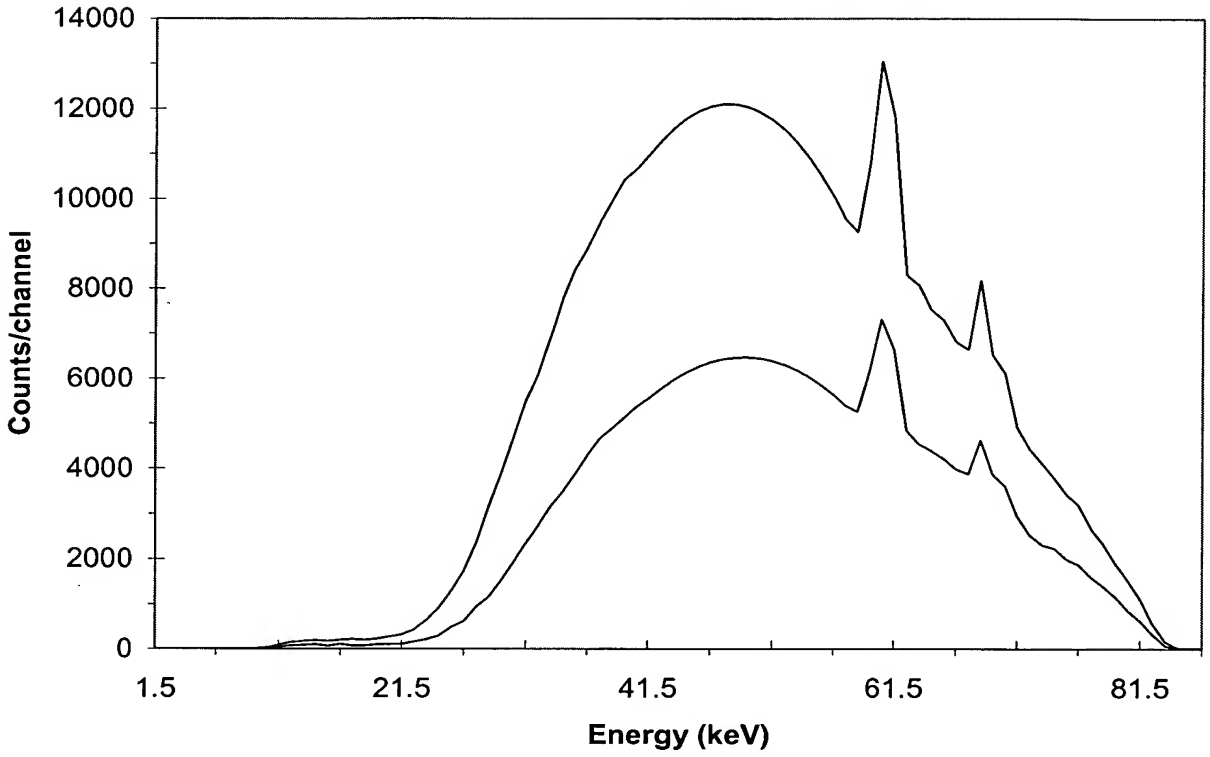
14000
12000
10000
8000
6000
4000
2000
0
Counts/channel
1.5
21.5
41.5
61.5
81.5
Energy (keV)

FIG. 21

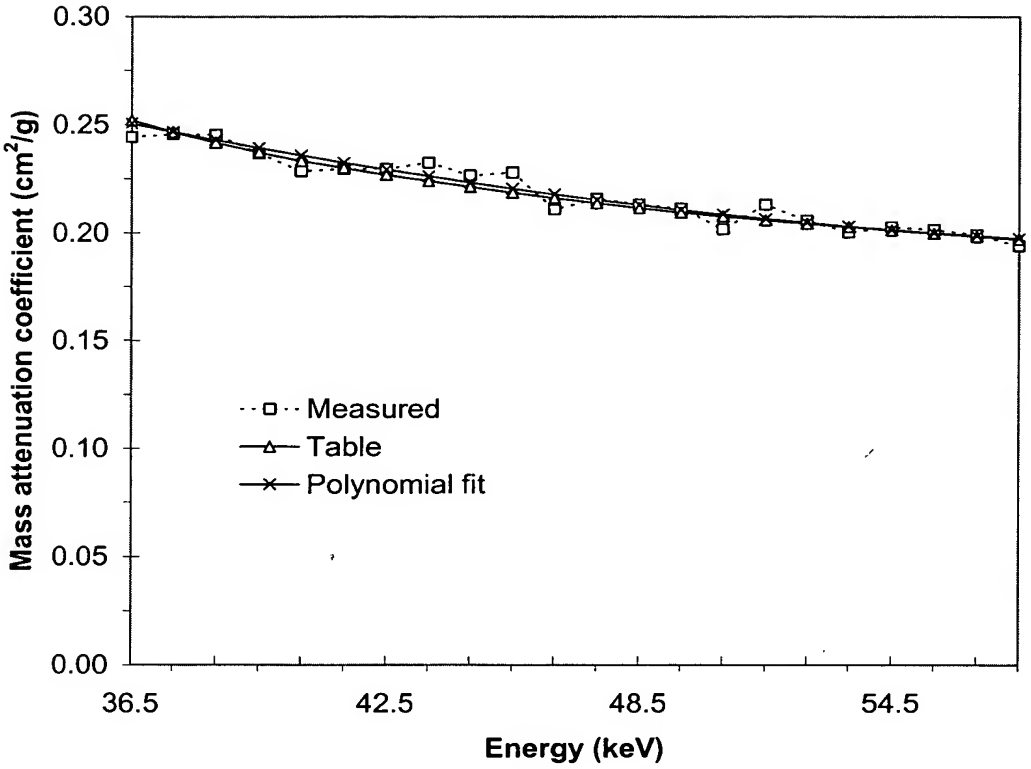
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Mass attenuation coefficient (cm²/g)
Measured
Table
Polynomial fit
36.5
42.5
48.5
54.5
Energy (keV)

FIG. 22

keV	μ/ρ experim.	μ/ρ theoret.	Ratio	$\sigma_{(\mu/\rho)}$
36.5	0.2505	0.2520	0.994	0.0062
37.5	0.2467	0.2466	1.000	0.0060
38.5	0.2429	0.2417	1.005	0.0059
39.5	0.2393	0.2371	1.009	0.0058
40.5	0.2358	0.2333	1.011	0.0057
41.5	0.2325	0.2300	1.011	0.0056
42.5	0.2293	0.2269	1.010	0.0056
43.5	0.2262	0.2240	1.010	0.0055
44.5	0.2232	0.2212	1.009	0.0054
45.5	0.2204	0.2186	1.008	0.0052
46.5	0.2178	0.2161	1.008	0.0051
47.5	0.2152	0.2138	1.007	0.0053
48.5	0.2129	0.2116	1.006	0.0054
49.5	0.2106	0.2094	1.005	0.0054
50.5	0.2085	0.2076	1.004	0.0054
51.5	0.2065	0.2059	1.003	0.0055
52.5	0.2046	0.2043	1.002	0.0055
53.5	0.2029	0.2028	1.001	0.0056
54.5	0.2013	0.2012	1.000	0.0056
55.5	0.1999	0.1998	1.001	0.0057
56.5	0.1986	0.1984	1.001	0.0058
57.5	0.1974	0.1970	1.002	0.0058

FIG. 23

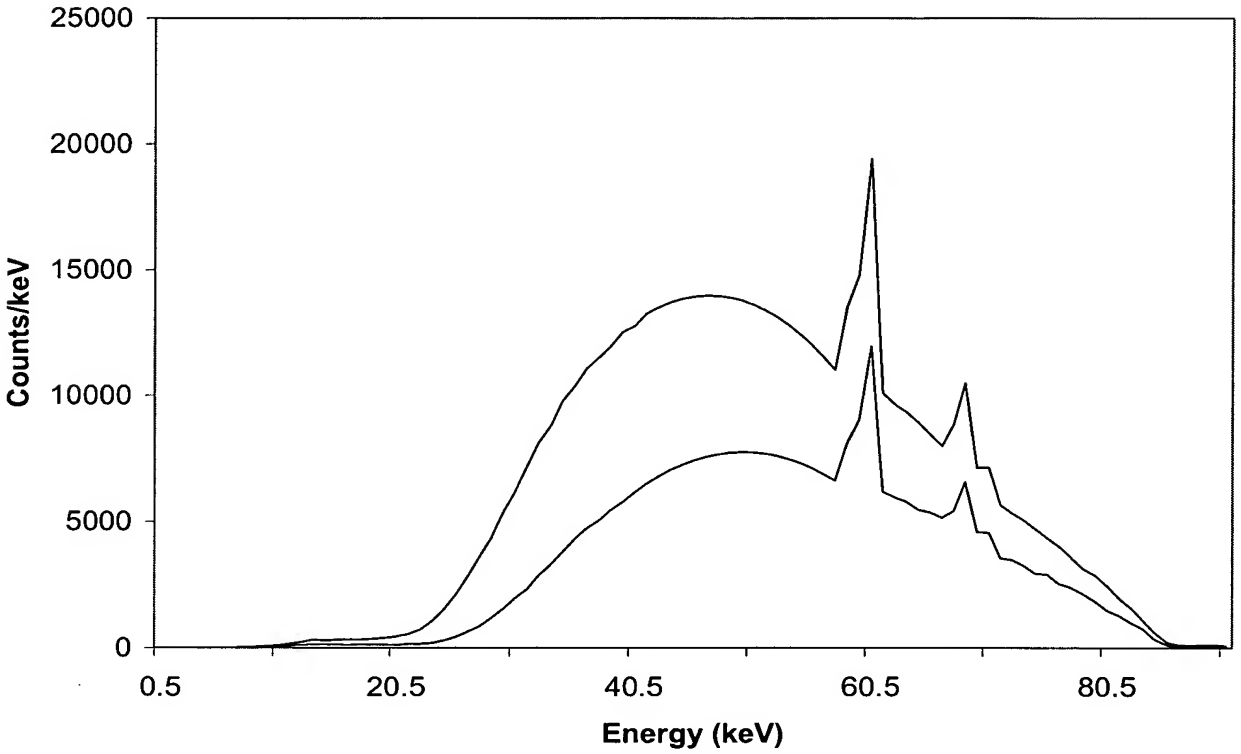
25000
20000
15000
10000
5000
0
Counts/keV
0.5
20.5
40.5
60.5
80.5
Energy (keV)

FIG. 24

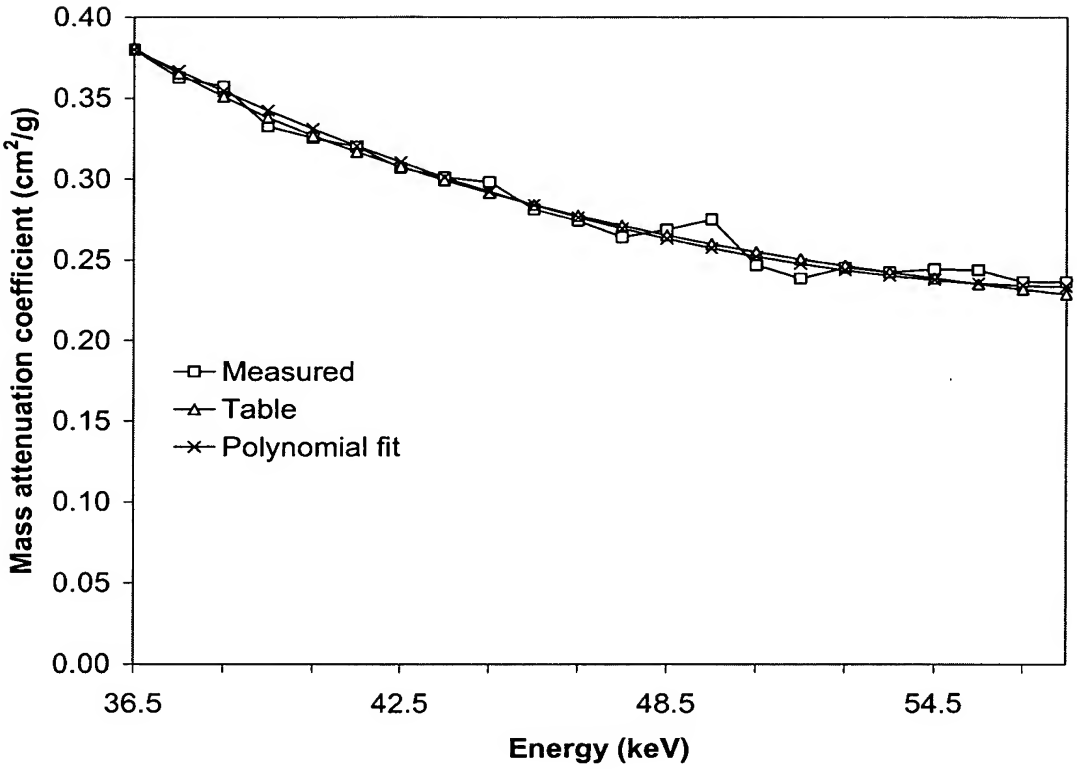
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Mass attenuation coefficient (cm²/g)
Measured
Table
Polynomial fit
36.5
42.5
48.5
54.5
Energy (keV)

FIG. 25

keV	μ/ρ experim.	μ/ρ theoret.	Ratio	$\sigma_{(\mu/\rho)}$
36.5	0.3799	0.3809	0.997	0.0078
37.5	0.3668	0.3652	1.004	0.0075
38.5	0.3543	0.3510	1.010	0.0073
39.5	0.3424	0.3380	1.013	0.0072
40.5	0.3311	0.3268	1.013	0.0071
41.5	0.3205	0.3169	1.011	0.0069
42.5	0.3104	0.3078	1.009	0.0069
43.5	0.3010	0.2993	1.006	0.0067
44.5	0.2922	0.2915	1.002	0.0065
45.5	0.2840	0.2842	0.999	0.0063
46.5	0.2764	0.2774	0.996	0.0064
47.5	0.2694	0.2711	0.994	0.0066
48.5	0.2631	0.2652	0.992	0.0066
49.5	0.2573	0.2598	0.990	0.0067
50.5	0.2522	0.2549	0.989	0.0067
51.5	0.2476	0.2505	0.988	0.0067
52.5	0.2437	0.2464	0.989	0.0068
53.5	0.2404	0.2424	0.992	0.0068
54.5	0.2377	0.2387	0.996	0.0069
55.5	0.2357	0.2351	1.002	0.0070
56.5	0.2342	0.2318	1.010	0.0070
57.5	0.2333	0.2286	1.021	0.0065

FIG. 26

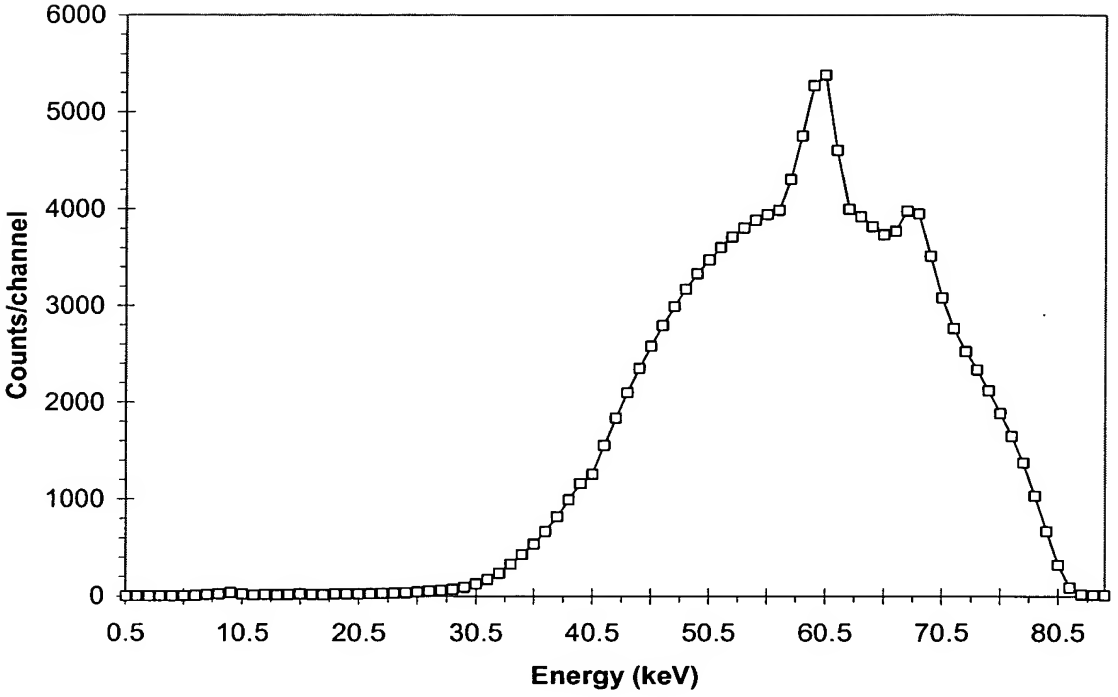
6000
5000
4000
3000
2000
1000
0
Counts/channel
0.5
10.5
20.5
30.5
40.5
50.5
60.5
70.5
80.5
Energy (keV)

FIG. 27

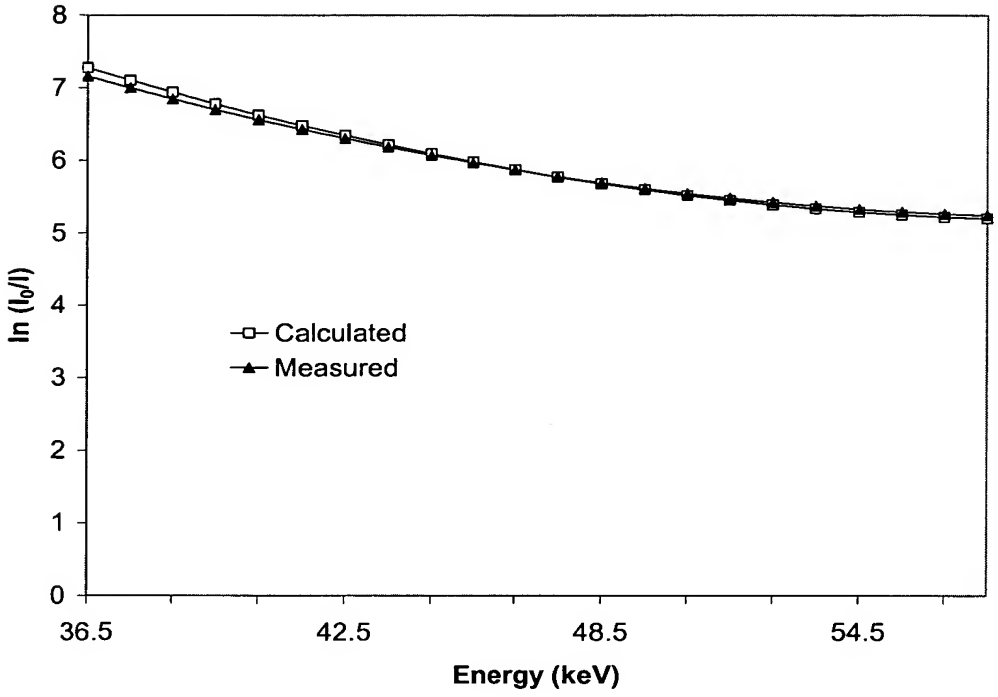
8
7
6
5
4
3
2
1
0
ln (I0/I)
Calculated
Measured
36.5
42.5
48.5
54.5
Energy (keV)

FIG. 28

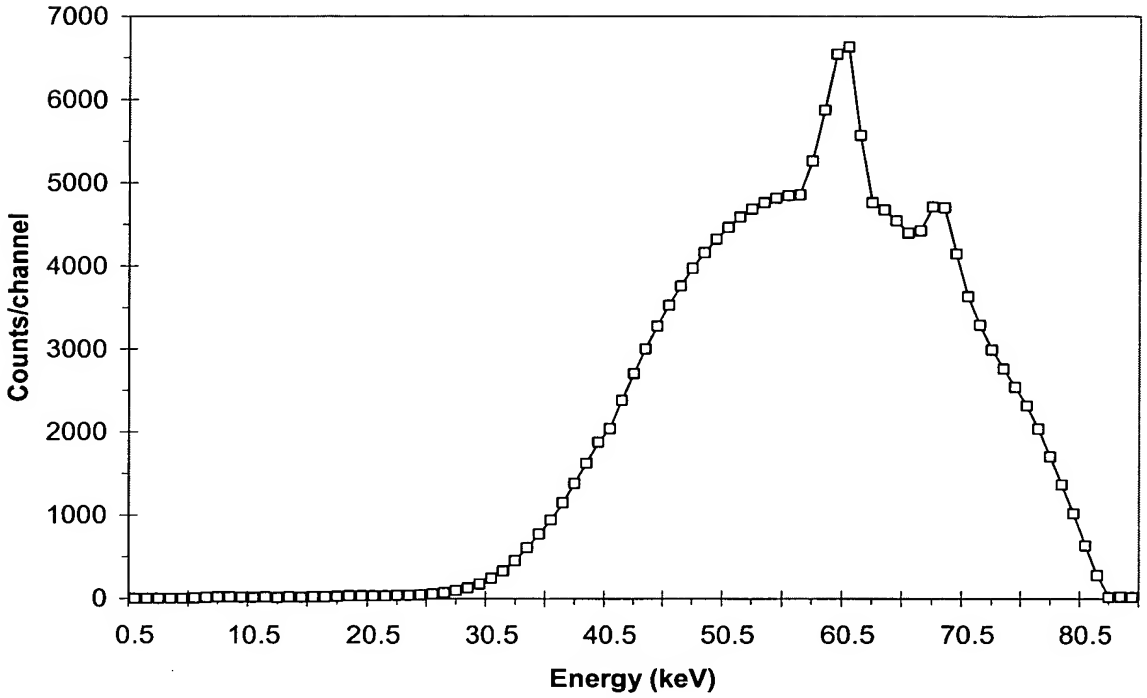
7000
6000
5000
4000
3000
2000
1000
0
Counts/channel
0.5
10.5
20.5
30.5
40.5
50.5
60.5
70.5
80.5
Energy (keV)

FIG. 29

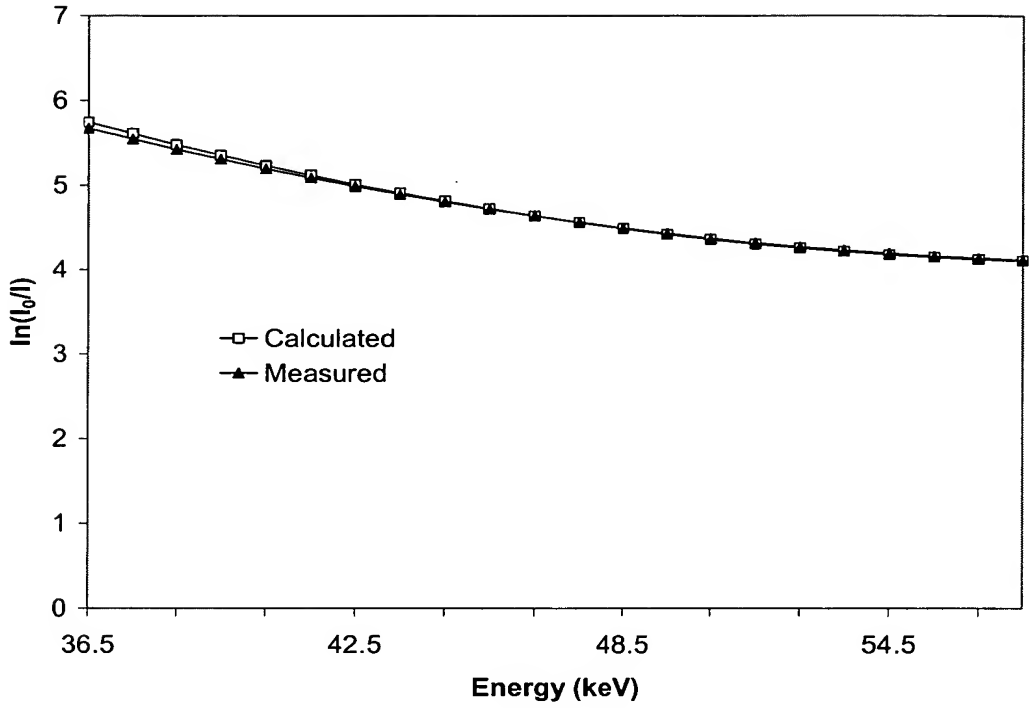
7
6
5
4
3
2
1
0
ln(I0/I)
Calculated
Measured
36.5
42.5
48.5
54.5
Energy (keV)

FIG. 30

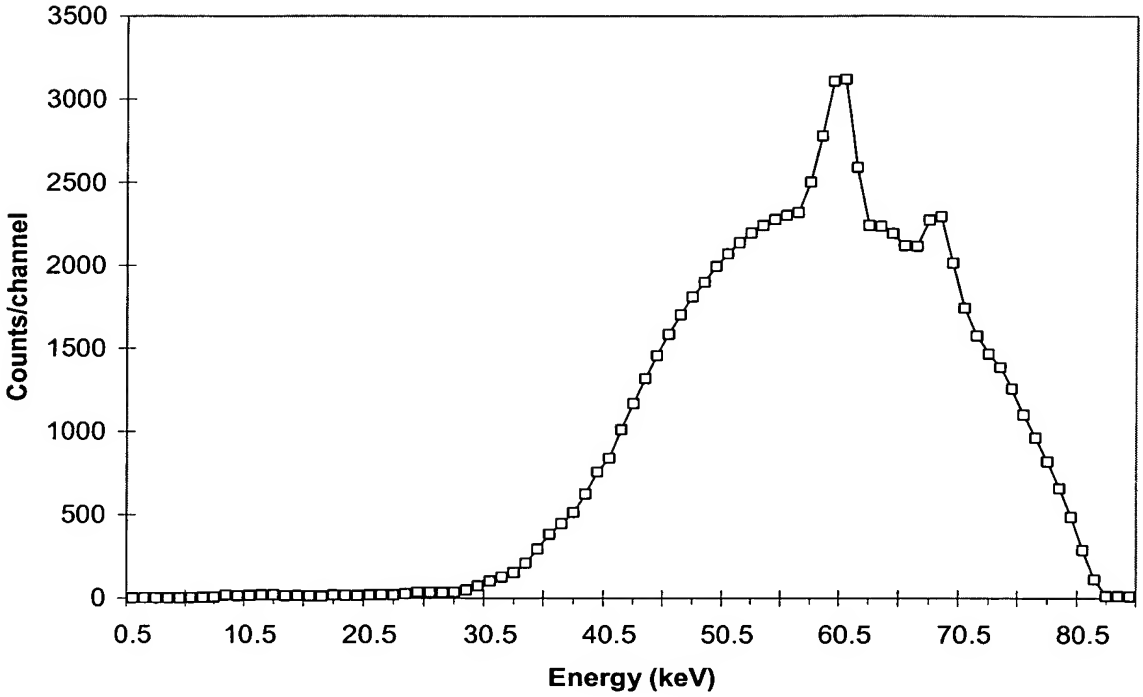
3500
3000
2500
2000
1500
1000
500
0
Counts/channel
0.5
10.5
20.5
30.5
40.5
50.5
60.5
70.5
80.5
Energy (keV)

FIG. 31

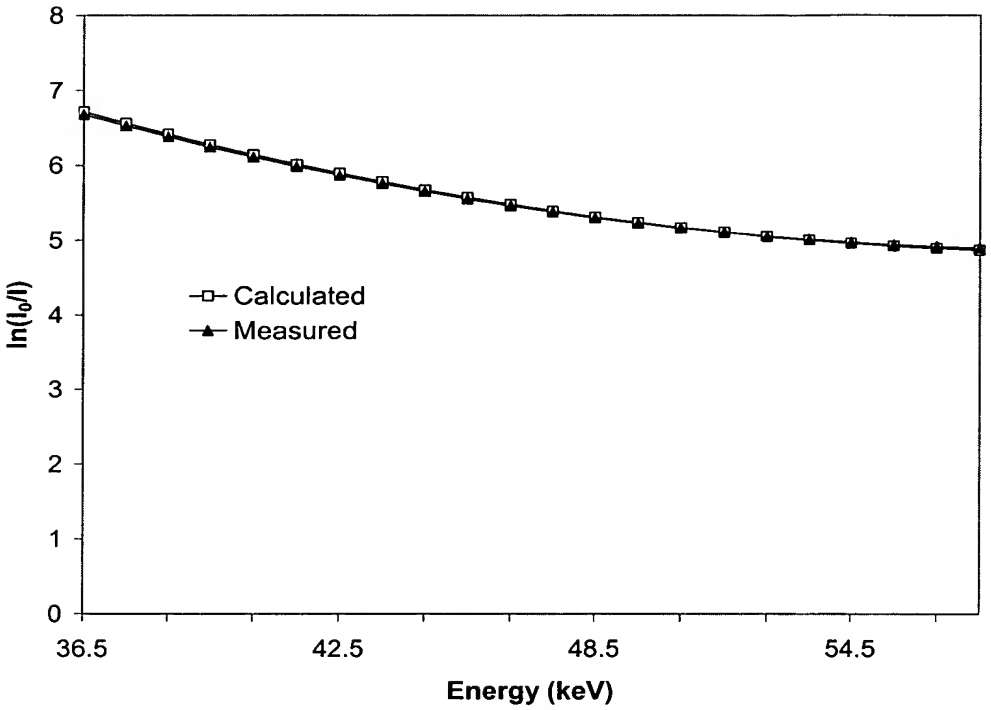
8
7
6
5
4
3
2
1
0
ln(I0/I)
Calculated
Measured
36.5
42.5
48.5
54.5
Energy (keV)

FIG. 32

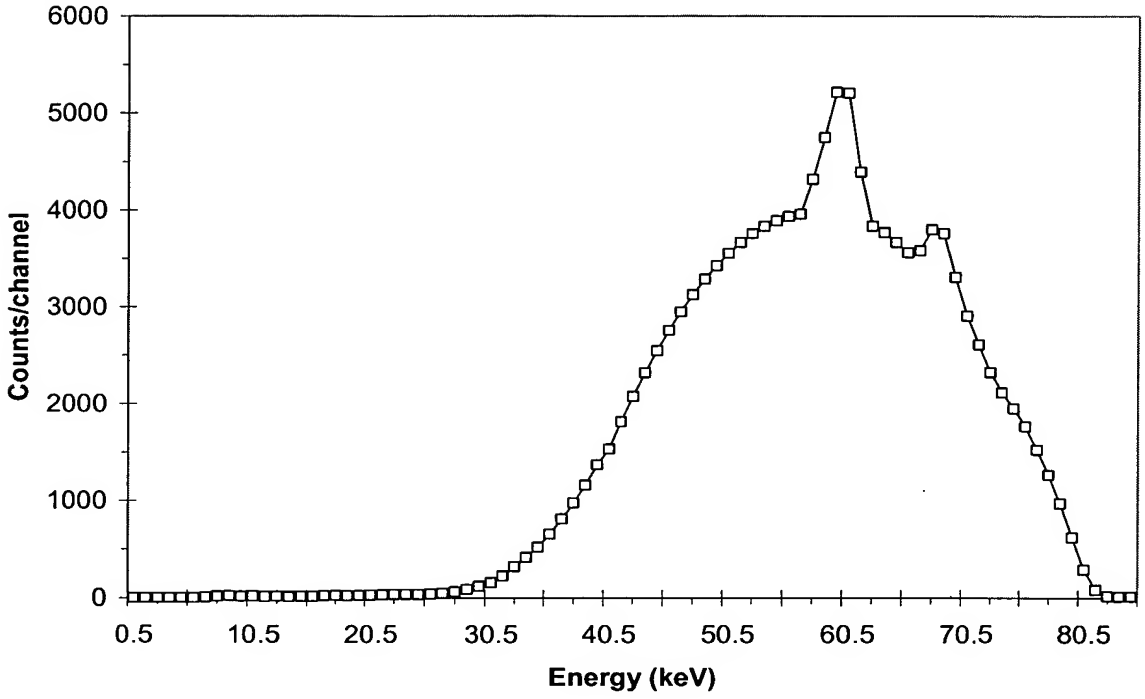
6000
5000
4000
3000
2000
1000
0
Counts/channel
0.5
10.5
20.5
30.5
40.5
50.5
60.5
70.5
80.5
Energy (keV)

FIG. 33

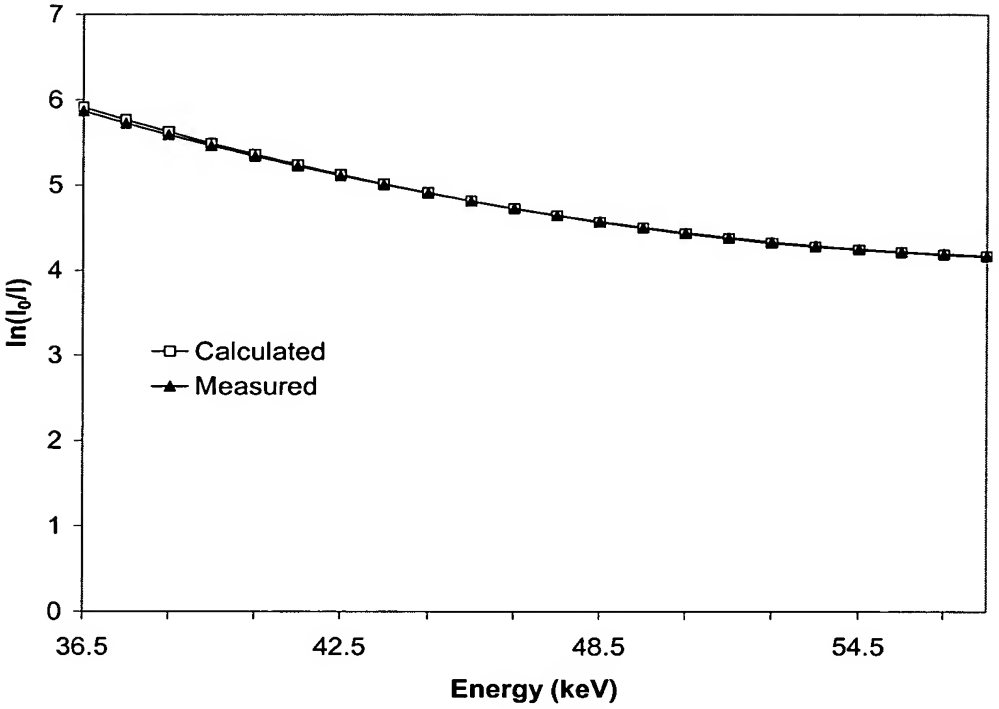
7
6
5
4
3
2
1
0
ln(I0/I)
Calculated
Measured
36.5
42.5
48.5
54.5
Energy (keV)

FIG. 34

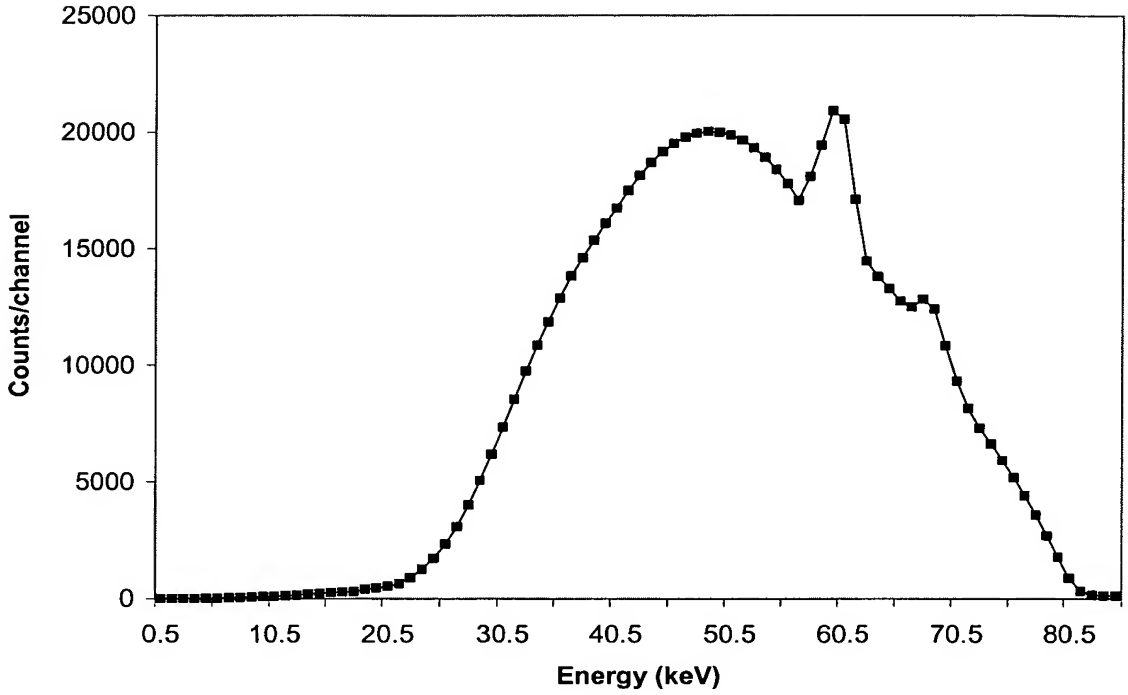
25000
20000
15000
10000
5000
0
Counts/channel
0.5
10.5
20.5
30.5
40.5
50.5
60.5
70.5
80.5
Energy (keV)

FIG. 35

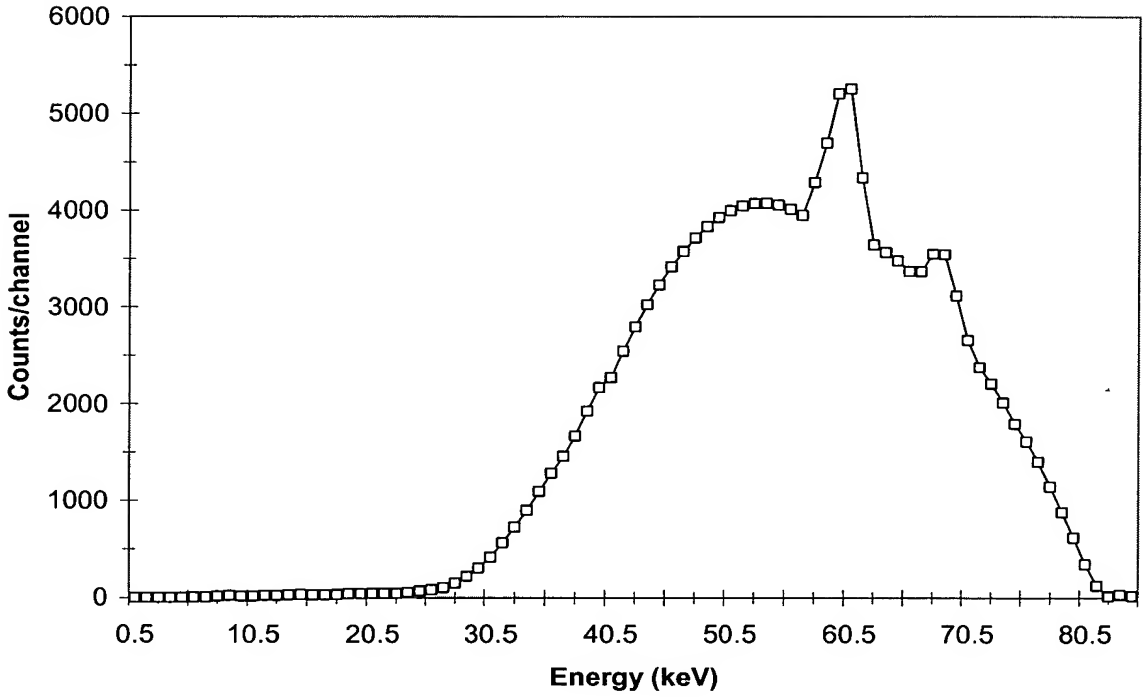
6000
5000
4000
3000
2000
1000
0
Counts/channel
0.5
10.5
20.5
30.5
40.5
50.5
60.5
70.5
80.5
Energy (keV)

FIG. 36

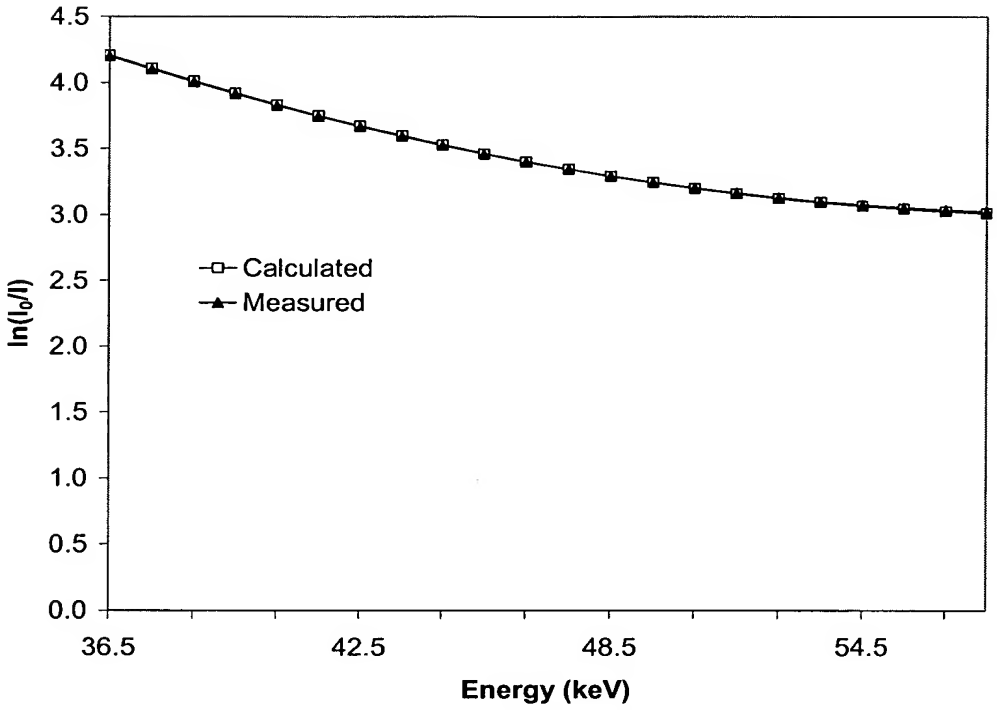
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ln(I0/I)
Calculated
Measured
36.5
42.5
48.5
54.5
Energy (keV)

FIG. 37

True values	**25.225**	**19.915**	**23.783**	**20.999**	**14.605**
Energy intervals	Phantom 1	Phantom 2	Phantom 3	Phantom 4	Phantom 5
1	25.870	20.041	24.412	21.349	14.794
2	25.225	19.738	23.581	20.908	14.401
3	25.944	19.930	24.691	21.371	14.897
4	25.825	20.074	24.281	21.322	14.738
5	25.048	19.966	24.837	21.432	14.957
6	26.066	19.969	24.867	21.443	14.971
7	26.034	19.965	24.815	21.426	14.949
8	26.046	19.964	24.836	21.431	14.958
9	26.006	19.959	23.783	21.407	14.928
10	26.117	19.963	24.972	21.471	15.013
Average	**25.818**	**19.957**	**24.507**	**21.356**	**14.861**

FIG. 38

True values	21.240	15.930	15.930	15.930	10.620
Energy intervals	Phantom 1	Phantom 2	Phantom 3	Phantom 4	Phantom 5
1	21.679	16.013	16.307	16.183	10.681
2	21.139	15.791	15.752	15.765	10.541
3	21.741	15.924	16.494	16.200	10.756
4	21.641	16.039	16.220	16.163	10.641
5	21.828	15.953	16.591	16.246	10.800
6	21.843	15.956	16.612	16.254	10.809
7	21.817	15.952	16.576	16.241	10.794
8	21.826	15.951	16.591	16.245	10.800
9	21.793	15.947	16.545	16.226	10.778
10	21.887	15.950	16.681	16.275	10.839
Average	**21.719**	**15.948**	**16.437**	**16.180**	**10.744**

FIG. 39

True values	2.901	2.901	6.769	2.901	2.901
Energy intervals	Phantom 1	Phantom 2	Phantom 3	Phantom 4	Phantom 5
1	3.104	3.026	7.080	3.053	3.092
2	3.027	2.783	6.626	2.906	2.736
3	3.113	3.009	7.161	3.056	3.114
4	3.099	3.031	7.042	3.049	3.080
5	3.126	3.015	7.203	3.065	3.126
6	3.128	3.015	7.212	3.066	3.129
7	3.124	3.015	7.196	3.064	3.124
8	3.125	3.015	7.203	3.065	3.126
9	3.121	3.014	7.183	3.061	3.120
10	3.134	3.014	7.242	3.070	3.138
Average	**3.110**	**2.994**	**7.115**	**3.046**	**3.079**

FIG. 40

True values	**1.084**	**1.084**	**1.084**	**2.168**	**1.084**
Energy intervals	**Phantom 1**	**Phantom 2**	**Phantom 3**	**Phantom 4**	**Phantom 5**
1	1.087	1.002	1.025	2.114	1.021
2	1.059	1.165	1.203	2.237	1.123
3	1.090	0.997	1.037	2.116	1.028
4	1.085	1.004	1.020	2.111	1.017
5	1.094	0.998	1.043	2.122	1.032
6	1.095	0.998	1.044	2.123	1.033
7	1.093	0.998	1.042	2.121	1.032
8	1.094	0.998	1.043	2.122	1.032
9	1.092	0.998	1.040	2.119	1.030
10	1.097	0.998	1.049	2.126	1.036
Average	**1.089**	**1.016**	**1.055**	**2.131**	**1.038**

FIG. 41

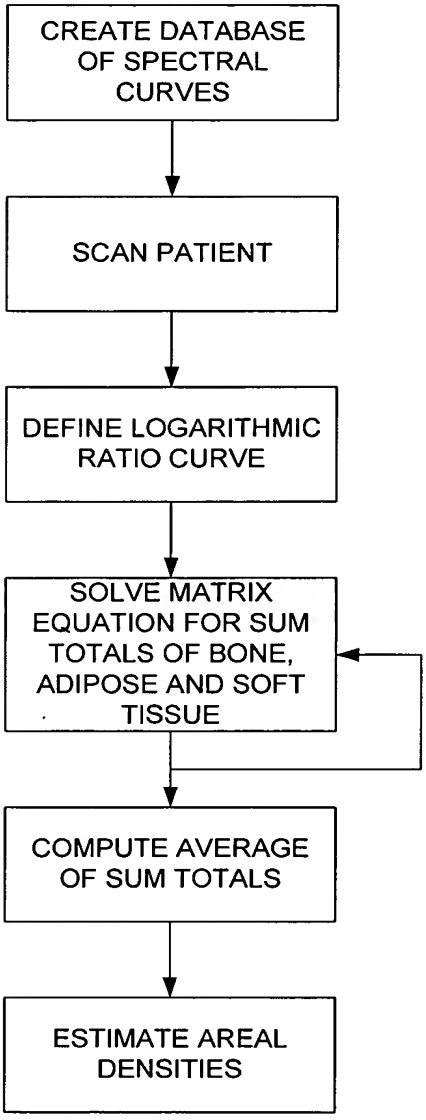
CREATE DATABASE OF SPECTRAL CURVES
SCAN PATIENT
DEFINE LOGARITHMIC RATIO CURVE
SOLVE MATRIX EQUATION FOR SUM TOTALS OF BONE, ADIPOSE AND SOFT TISSUE
COMPUTE AVERAGE OF SUM TOTALS
ESTIMATE AREAL DENSITIES

FIG. 42